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Response Of A Rice Variety To The Combined Intakes Of P With Organic Amendments In Acidic Soils Of Moist Forest Regions In Cote D'ivoire

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Abstract

Phosphorus (P) is one of the major minerals essential for the plants development in general and that of rice in particular. In the acid soils of humid forest regions, phosphorus is the most restrictive element. Indeed, the fixing of oxides and hydroxides of iron and aluminum in a large quantity in these soils with phosphorus make this element little available for plant nutrition.

Soluble fertilizers used for P availability are not only inaccessible to small farmers because of their high cost, but increase soil acidity because of their low utilization rate when applied to the soil ground.

Spent Mushroom Substrates or « SMS », which are increasingly important in the subregion due to the development of mushroom cultivation, can be an alternative. Indeed, rich in organic matter and a slightly acidic pH, even neutral, the application of "SMS" in soils can reduce the sites of attachment of metal ions, and thus facilitate the availability of P.

An experiment in rice cultivation, conducted for this purpose in pots with two types of "SMS" S1 and S2 both based on red sawdust and rice straw in different rates, from the cultivation of mushroom *Pleurotus Eous var.* and combined with P at different doses, applied to desaturated ferralitic soil samples from moist forest regions, including Man and Abengourou respectively to the west and east of Côte d'Ivoire, effectively showed influence of these substrates on the availability of P. According to this experiment carried out with rice interspecific variety WAB 450-IB-P38-HB implemented by AfricaRice, the incorporation of substrates S1 or S2 combined with P increases the availability of P as well as grain and straw yields. Specifically, composite samples of Man, a soil that is more acidic than Man, provide maximum grain and straw yield for incorporation of 30 µl of S2. Those of Abengourou allow the same yields for incorporation of 15 p.c. of S1 or S2.

Keywords: acid soils, rice, phosphorus, solubility, wet humid forest, organic material, spent mushroom substrates

1.Introduction

Soil fertility is one of the major constraints of crop production in general and rice cultivation in particular. In the acidic soils of moist forest regions, phosphorus (P) bonds with iron and aluminum oxides and hydroxides in large quantities do not allow P availability for the nutrition of rice plants (Lindsay, 1977, Uexküll & Mutert, 1995, Sarhawat et al., 2008).

According to Hewitt in 1952, the pH range between 2.5 and 6, and corresponding to acid soils is very favorable to the fixation of phosphate ions. The contributions of soluble P in simple and / or compound form can correct deficiencies temporarily (Fairhurst and Warren, 1992, Sahrawat et al., 1997, Nguyen, 2003, Arai and Sparks, 2007), but are the cause continuous soil acidification. Indeed, only a small part of these contributions of P contributes effectively to the nutrition of the rice plants, the rest in turn generates during the process of fixing P, the release of hydrogen ions at the origin this acidification.

To increase the availability of P in acid soils, several methods are used. The addition of inert lime by raising its pH (Brown and Stecker 2003, Essington, 2004) makes it possible to move the soil from the critical fixation area of P. Similarly, a contribution of low acid organic matter allows many Studies would increase the rate of release of P retained in soils, thus increasing the availability of it for plant nutrition.

"Spent Mushroom Substrates", or abbreviated "SMS" or residual substrates for the production of edible fungi, is an important source of compost that can promote the availability of P in acid soils. Indeed, these substrates unlike many others are very weakly acidic, even neutral, mandatory requirement for efficient development of mushroom crops. Which they come from

In recent years, the development of mushroom cultivation makes available huge amounts of SMS.

The purpose of this study is to evaluate the response of a rice variety of the NERICA species to the combined inputs of P with residual substrates to fungal production.

2. Material and methods

2.1 Field of study

The experiment was conducted at the production station of the Technical Support, Control and Research Center (CATCR) of the company

- Residual substrate for mushroom production

ARIES.SA, in Abengourou in eastern Côte d'Ivoire. This center is located at the entrance of the city at 6.7 ° N and 3.5 ° W and at an altitude of 215 m. The department of Abengourou is part of the humid forest zone. It is characterized by a gentle terrain consisting of plateaus and small hills. This relief is watered by the Comoé River and its tributaries. The vegetation consists of dense forest and savannah. Most of the soils are ferrallitic (ferralsols) at plateaux and hydromorphy in lowlands.

The climate of the zone is of Baoulean type with four seasons, i) a big dry season of four months (November-February); (ii) a large four-month rainy season (March-June); iii) a short dry season of two months (July-August) and iv) a small rainy season two months (end of August-end of October). Rainfall varies between 1600 and 2100 mm of rain per year. The thermal amplitude is low, and the average annual temperature is 26 ° (SODEXAM, 2005). The soils of the region are mostly ferrallitic. The experimental site is located midway up a slope.

2.2 Floors used

They consist of composite samples collected in the 0-20 and 20-40 cm horizons respectively in the Abengourou and Man zones, a department also located in the humid forest zone in western Côte d'Ivoire. The soils of Man and Abengourou are both ferrallitic respectively strongly and moderately desaturated. Samples of each soil type were mixed and sieved. Only fractions passing the 2 mm sieve were used.

2.3 Plant material

It consists of an interspecific variety of rice of the species NERICA V=WAB450-1-B-P38-HB developed by the Africa Rice Center (AfricaRice).

2.4 Fertilizers used

Two residual substrates for the production of edible fungus Pleurotus Eous var. (S1 and S2) were used.

Substrate 1 (S1) is the residual of a compost originally composed in volume proportion by red sawdust (63 pc), rice straw (9 pc), rice bran (2 pc), inert lime (1 pc) and water (25 pc). The substrate (S2) comes from a compost originally constituted in volume proportion by red sawdust (22 pc), rice straw (50 pc), rice bran (2 pc), inert lime (1 pc) and water (25 pc).

2.5 Mineral fertilizers

Triple superphosphate (TSP) was used as a source of P. Urea (46% N) and potassium (KCl 60% K2O) are provided in addition.

2.6 Experimental apparatus

The experiment was conducted according to a completely randomized block factorial device, with three (03) factors following three (03) repetitions.

As factors, we have:

- Seeds of rice of the variety WAB 450-I-B-P38-HB brought on account of 60 kg ha-1. The seeds were pregerminated before being transplanted due to three (03) plants in each pot according to the seeding density;
- 10 kg of soil per pot (Man's soil or Abengourou soil) were combined at 0; 5; 10; 15 and 30 t ha^{-1} respectively by the substrates S1 and S2;
- Phosphate fertilizer (triple superphosphate) supplied according to the P0 doses; P25; P50; P75 and P100 respectively corresponding to 0; 25; 50; 75 and 100 kg of P.ha-1.

That is a total of 225 pots due to seventy-five (75) per repetition. TSP was brought at planting time. Urea and potassium were also added in addition to phosphorus, respectively, because of 20 and 40 kg.ha-1 at sowing, tillering and spur for urea and 50 kg ha -1 at sowing for potassium. Figure 1 shows a diagram of the experimental device.

2.7 Observations and measurements

In order to characterize the soils used for the test, a soil profile was opened in each of the sampled areas. A description of said profiles has been made. Prior to TSP, composite soil samples and samples combined with substrates were analyzed in the laboratory. On these samples, total P was determined, P assimilated by the Bray method (Bray & Kurtz, 1945), and pH. At harvest, the weights of grains and straw by treatment were measured. Similarly, one rice plant per treatment was removed at this stage, and root weight and P content were determined to determine the P exported.

2.8 Calculated and evaluated parameters

From the data collected, grain and straw yields per treatment were evaluated at 14% relative humidity and P exports. Similarly, the agronomic efficiency and the apparent rate of P use were calculated (Wissawa et al., 2009).

2.9 Statistical treatment of data

The statistical processing of the data was done from the software Statistix version 9.0. The tables and figures were developed from the Microsoft Excel spreadsheet.

Designation	Soil +substrate	TSP				
		P0	P25	P50	P75	P100
SMS1- Pi	SM+0 % S1					
	SM+5 % S1					SM+0 % S1+ 100 kg de Pha^{-1} (SMS1- P100)
	SM+10 % S1					
	SM+15 % S1					
	SM+30 % S1					

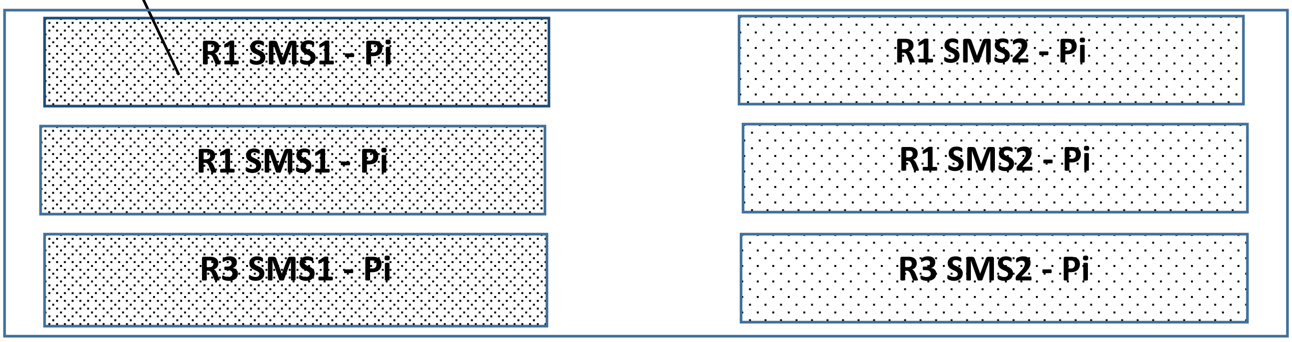

Figure 1. experimental apparatus

3. Results

3.1 Soils of the sites

Soils from different experimental sites are ferrallitic types (ferralsols). Specifically, that of Man is strongly desaturated in bases, reworked, weakly rejuvenated and derived from granite with hyperstene. As for the soil coming from Abengourou, it is moderately desaturated in bases, reworked, modal, and resulting from shale. Man's soil is deeper (> 155 cm) than Abengourou's, limited by a carapace from 91 cm. The physicochemical characteristics of the sites' soils are given in Table II. According to these, the two soils have almost the same texture (Man: sand - clay to clay - sandy, Abengourou: sand - clay) in the horizons used (0-40 cm). The levels of fine silt are low (on average 40 g / kg). The rate of clay decreases surface horizons towards the depths, and this rate is higher on the soil of Man (on average 470 g / kg), than on the ground of Abengourou (on average 280 g / kg). Unlike clay, the Abengourou soil contains more coarse sand (averaging 260 g / kg) than Man's (averaging 180 g / kg). The soils are both poor in assimilable P and total P. Man's soil is more acidic (pH water = 4.4) than that of Abengourou (pH water = 5.2); its Al and Fe contents are higher. Abengourou soil has a higher cation exchange capacity (10.3 cmol (+) kg-1) than Man's (5.29 cmol (+) kg-1).

3.2 Composite soils and substrates

The results of the chemical analyzes of the substrates (S1 and S2) are shown in Table 1. The substrates have a practically neutral pH. Substrate S1, however, is slightly more acidic (pH = 6.9) than substrate S2 (pH = 7.1). Both substrates are rich in organic matter, and have a moderately high nitrogen content. Their phosphorus content is low, as is their potassium content. The C / N ratios close to 15 (16.1 and 17.8 respectively for the substrates S1 and S2) indeed reflect the high level of degradation of the organic matter generated by the mushroom culture. The results of the chemical analyzes of composite soils (soils +% of substrate) before P input are recorded in Table 2. These soils are generally acidic, and those of Man are more acidic (pH between 4.3 and 5.1) than those of Abengourou (pH between 5.1 and 5.8) despite the contribution of substrates.

The addition of substrates raises the pH, and improves other parameters such as: CEC, total nitrogen, organic carbon and P content. The mobilization of P is more increased in composite soils, and reaches in average 18 mg Pkg-1 soil compared with 6.5 mg Pkg-1 soil for Abengourou soil and 11 mg Pkg-1 soil compared to 2.6 mg Pkg-1 soil for the floor of Man.

Table 1: Physico-chemical characteristics of soil sites

	Horizon soil of Man					*Horizon soil ofAbengourou*		
Tests	*0-20*	*20-50*	*50-70*	*70-155*	*>155*	*0-22*	*22-43*	*43-91*
Granulometry (g.kg⁻¹)								
clay	370	420	440	430	290	240	300	310
Fine silt	30	30	10	40	40	40	40	40
Coarse silt	200	160	140	150	200	170	200	160
Fine sand	240	230	210	190	230	280	230	230
Coarse sand	150	160	190	160	230	310	230	260
pH eau	4,4	4,6	4,6	4,6	5,2	5,2	5,4	5,4
pH (1M KCl)	3,8	3,8	3,9	3,9	4,5	4,7	4,8	4,8
pF 4,2	12,2	13,2	14,6	15	13,4	10,6	10,9	11,2
pF 2,5	17,2	17,5	18,6	19,4	18,1	14.7	15,1	16,0
CEC (cmol (+).kg^{-1})	5,29	13,08	7,88	6,20	9,20	10,3	15,2	12,9
Saturation rate								
Exchangeable bases (cmol (+).kg^{-1})								
K	0,05	0,33	0,03	0,04	0,35	0.27	0,34	0.09
Mg	0,18	0,12	0,15	0,36	0,02	0,17	0,21	0,32
Na	0,06	0,51	0,06	0,09	0,07	0,08	0,09	0,11
Ca	0,54	0,32	0,32	0,73	0,33	0.83	0,79	0,71
Al (cmol (+).kg^{-1})	0,97	0,98	0,76	0,32	-	0,74	0,81	0,56
Fe extratable (mg/kg)	53,6	27,2	179,4	65,8	18,2	43,6	52,3	79,4
P. Bray 1 (mg/kg)	2,6	1,75	0,5	0,9	0,5	6,5	5,3	2,1
P. total (mg/kg)	300	170	120	72	14	248	172	109
Organic carbon (g/kg)	13,0	7,2	3,1	0,9	0,2	12,0	6,8	2,7
Total nitrogen: N (mg/kg.)	790	350	190	90	-	450	290	160
[1]m = (Al x 100)/ (Al +SBE*)	53,9	43,4	57,6	20,8		35,4	36,2	31,3

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Table 2: Chemical characteristics of substrates and composite soil samples

Parameters	pH water	P. assimilable (mg de Pkg^{-1})	P total (mg de Pkg^{-1})	CEC (cmol (+).kg^{-1})	C (p.c.)	N total (mg/kg)
Soil of Man	4,3	2,6	300	5,29	1,30	790
Soil of Abengourou	5,1	6,5	248	10,3	1,20	450
SAS1-5	5,4	8,1	281	7,9	4,2	840
SAS1-10	5,6	9,7	294	10,4	5,6	890
SAS1-15	5,7	11,8	306	13,1	8,3	960
SAS1-30	5,6	12,1	328	14,3	10,6	1100
SAS2-5	5,7	9,3	269	8,4	4,6	870
SAS2-10	5,7	11,2	282	11,3	5,5	920
SAS2-15	5,8	17,6	283	15,7	8,2	1040
SAS2-30	5,7	16,2	298	16,3	10,1	1140
SMS1-5	4,6	4,9	305	6,8	5,4	520
SMS1-10	4,6	5,7	326	7,2	7,6	590
SMS1-15	4,6	8,9	335	8,9	8,9	620
SMS1-30	4,7	9,1	356	9,1	10,8	1670
SMS2-5	4,6	6,1	301	7,6	3,8	580
SMS2-10	4,7	8,3	315	8,4	7,3	650
SMS2-15	4,7	9,8	312	14,3	9,4	740
SMS2-30	5,1	10,7	341	14,2	11,1	810
	C (p.c.)	**N** (mg/kg)	**P** (p.c.)	**C/N**	**K** (p.c.)	**pH eau**
S1	15,6	970	0,48	16,1	0,04	6,9
S2	18,3	1030	0,67	17,8	0,12	7,1

3.3 Grain and straw yields

The average grain and straw yields (Tables 3 to 6) vary according to the types of soils, the nature and the level of substrate used but also the dose of TSP applied. The analysis of the yield variances shows a significant difference in the levels and nature of the substrates, the type of soil, the doses of TSP made, and finally combinations of all these factors. Yields are generally higher at the levels of Abengourou composite soils.

♣ At the level of Abengourou

The average grain and straw yields are, respectively, 1999 kg ha-1 (Table 3) and 2265 kg ha-1 (Table 4) regardless of the dose of TSP, the nature and the rate of substrate applied. These average grain and straw yields are, respectively, 2050 and 2321 kg ha-1, whatever the nature and the rate of substrate applied. They are 2029 kg / ha and 2279 kg ha-1 for the substrate 1, and 2072 kg ha-1 and 2363 kg ha-1 for the substrate 2. For the TSP, the average grain and straw yields vary according to the doses applied TSP, respectively, from 1326 kg ha-1 to 2343 kg ha-1 and from 1502 kg ha-1 to 2656 kg ha-1.

♣ At the level of Man

The average grain and straw yields are, respectively, 1861 kg ha-1 (Table 5) and 2114 kg ha-1 (Table 6) regardless of the dose of TSP, the nature and the rate of substrate applied. These average yields grain and straw are, respectively, of 1914 and 2177 kg ha-1 whatever the nature and the rate of substrate applied. They are 1887 kg ha-1 and 2146 kg / ha for the substrate 1 and 1940 kg ha-1 and 2208 kg ha-1 for the substrate 2. For the TSP, the average grain and straw yields vary according to the doses of TSP applied, respectively, from 1159 kg ha-1 to 2229 kg ha-1 and from 1317 kg ha-1 to 2533 kg ha-1.

♣ Combination of factors and LSD

The application of LSD at the 5-point threshold confers: at the P100 treatment, the highest grain and straw yields for the substrate 1; at the P75 treatment, the highest grain and straw yields for the substrate 2; at the incorporation rate of 15 µl of substrates, the optimum grain and straw yields for the substrate 1, and also for the substrate 2 at Abengourou; at the rate of incorporation of 30 µl of substrates, the maximum grain and straw yields for the substrate 2 at Man.

In addition,

- without the addition of TSP (P0), grain and straw yields are higher in Abengourou than in Man;
- without the addition of substrate, grain and straw yields are higher at
- level of Abengourou than Man, regardless of the dose of TSP applied.

On the other hand, grain-straw yields increase with the availability of P in the composite soils of both Abengourou and Man (Figure 2 and 3). The coefficients of determination of trend curves established between yields and P availability are significant at the levels of Man's composite soils. In other words, in very acidic soils such as those of Man, the availability of P favored by the inputs of substrates is a determining factor as to the increase in yields. Moreover, the increase in yields with the increasing contributions of TSP, soluble fertilizer immediately available from application only reinforce this assertion.

Table 3: Average grain yield (kg ha-1) according to the TSP input, the nature and the substrate content at the composite soil level (Abengourou)

Treatment	Adding of TSP					Average
	P0	P25	P50	P75	P100	
SA	1257	1775	2001	2214	2238	1897
SAS1-5	1253	1803	2054	2219	2297	1925
SAS1-10	1301	1872	2045	2275	2351	1969
SAS1-15	1386	1957	2226	2528	2465	2112
SAS1-30	1412	1977	2248	2482	2420	2108
Average SAS1	*1338 d*	*1902 bc*	*2143 ab*	*2376 a*	*2383 a*	*2029*
SAS2-5	1284	1819	2078	2248	2323	1950
SAS2-10	1349	1894	2116	2357	2376	2018
SAS2-15	1473	1972	2272	2661	2490	2174
SAS2-30	1431	1998	2219	2641	2445	2147
Average SAS2	*1384*	*1921*	*2171*	*2477*	*2409*	*2072*
Average SAS	*1361*	*1912*	*2157*	*2427*	*2396*	*2050*
Average	**1326d**	**1866c**	**2105b**	**2356a**	**2343a**	**1999**

Online averages (in columns, respectively) followed by different letters, differ significantly (P < 0,05)

Table 4: Average straw yield (kg ha-1) according to the TSP input, the nature and the substrate rate at the level of composite soils (Abengourou)

Treatment	Adding of TSP					Average
	P0	P25	P50	P75	P100	
SA	1433	2006	2265	2526	2533	2153
SAS1-5	1420	2025	2329	2536	2605	2183
SAS1-10	1475	2108	2323	2606	2673	2237
SAS1-15	1572	2225	2538	2887	2815	2407
SAS1-30	1603	2254	2576	2849	2788	2414
Moyenne SAS1	*1500*	*2123*	*2406*	*2681*	*2683*	*2279*
SAS2-5	1455	2046	2359	2572	2637	2214
SAS2-10	1531	2135	2406	2701	2704	2295
SAS2-15	1673	2244	2595	3042	2846	2480
SAS2-30	1626	2282	2545	3035	2819	2461
Average SAS2	*1571*	*2177*	*2476*	*2837*	*2751*	*2363*
Average SAS	*1536*	*2150*	*2441*	*2759*	*2717*	*2321*
Average	**1502d**	**2102c**	**2382b**	**2681a**	**2656a**	**2265**

NB: SA (Soil of Abengourou) SASi (Abengourou Soil associed with substrat i p.c.)
Online averages (in columns, respectively) followed by different letters, differ significantly (P < 0,05)

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Table 5: Average grain yield (kg ha-1) according to the TSP input, the nature and the substrate rate at the composite soil level (Man)

Treatment	Adding of TSP					Average
	P0	P25	P50	P75	P100	
SM	1061	1629	1897	2054	2141	1756
SMS1-5	1119	1691	1928	2121	2179	1808
SMS1-10	1157	1759	2012	2173	2278	1876
SMS1-15	1214	1795	2076	2245	2351	1936
SMS1-30	1226	1825	2037	2326	2237	1930
Average SMS1	*1179*	*1768*	*2013*	*2216*	*2261*	*1887*
SMS2-5	1153	1703	1954	2119	2197	1825
SMS2-10	1201	1772	2045	2176	2271	1893
SMS2-15	1276	1835	2126	2448	2327	2002
SMS2-30	1322	1903	2168	2468	2338	2040
Average SMS2	*1238*	*1803*	*2073*	*2303*	*2283*	1940
Average SMS	*1209*	*1785*	*2043*	*2260*	*2272*	*1914*
Average	**1159d**	**1733c**	**1995b**	**2191a**	**2229a**	**1861**

Online averages (in columns, respectively) followed by different letters, differ significantly (P < 0,05)

Table 6 : Average straw yield (kg ha-1) according to the TSP input, the nature and the substrate content at the level of composite soils (Man)

Treatment	Adding of TSP					Average
	P0	P25	P50	P75	P100	
SM	1210	1824	2144	2342	2419	1988
SMS1-5	1268	1896	2182	2420	2467	2047
SMS1-10	1312	1977	2282	2482	2586	2128
SMS1-15	1377	2037	2362	2559	2680	2203
SMS1-30	1392	2077	2330	2666	2573	2207
Average SMS1	*1337*	*1997*	*2289*	*2532*	*2576*	*2146*
SMS2-5	1306	1911	2214	2420	2489	2068
SMS2-10	1363	1994	2321	2487	2580	2149
SMS2-15	1448	2085	2422	2796	2655	2281
SMS2-30	1502	2168	2482	2831	2693	2335
Average SMS2	*1405*	*2039*	*2360*	*2633*	*2604*	*2208*
Average SMS	*1371*	*2018*	*2324*	*2583*	*2590*	*2177*
Average	**1317d**	**1953c**	**2264b**	**2502a**	**2533a**	**2114**

NB : SM (Soil of Man) SMSi (Man soil associed of substrate i p.c.)
Online averages (in columns, respectively) followed by different letters, differ significantly (P < 0,05)

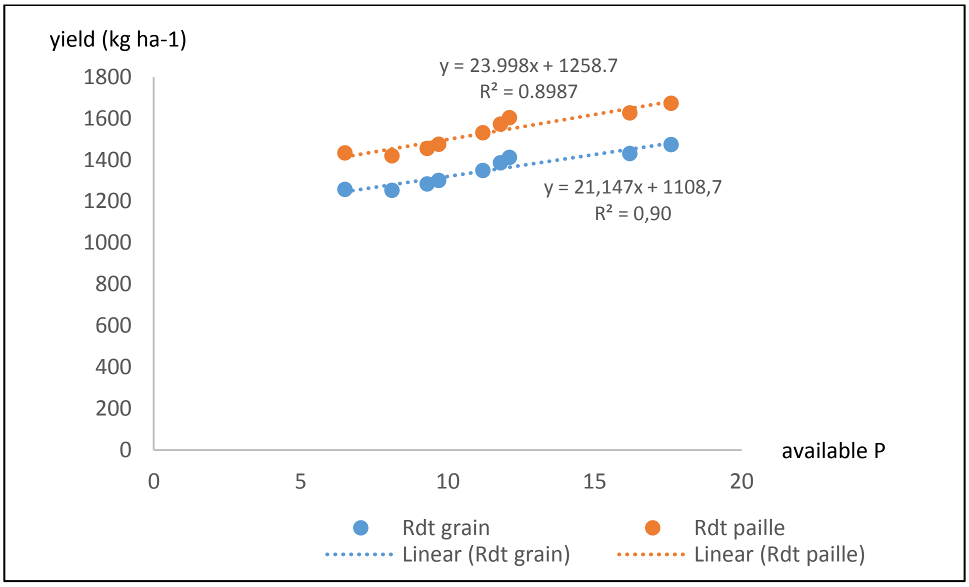

Figure 2 : Evolution of yields according to the availability of P in soils composites of Abengourou

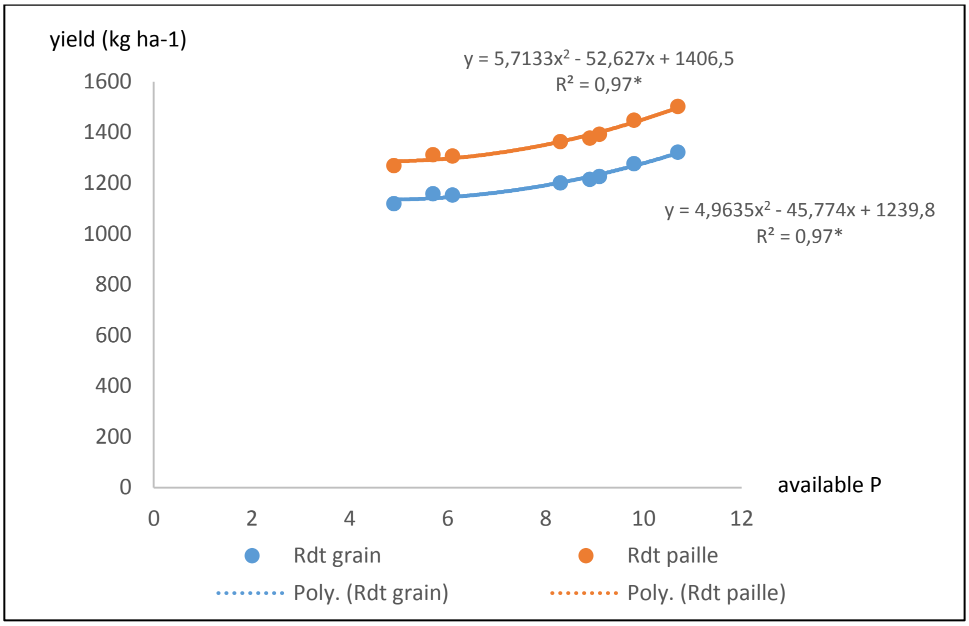

Figure 3: Evolution of yields according to the availability of P in composite soils of Man

3.4 P exports

Exports of P (Tables 7 and 8) are relatively higher in Abengourou (3.3 kg of Pha-1) than in Man (2.8 kg of Pha-1). They increase with the nature and the level of substrates incorporated in the soil, as well as with the dose of TSP applied. They are higher at the soil levels in which the S2 substrate has been incorporated, compared to those having received the S1 substrate. At the Abengourou soil levels, P exports range from an average of 3.3 to 6.3 kg of Pha-1 following the doses of TSP applied without substrate input. These exports range from 3.3 to 3.8 kg of Pha-1 and 3.3 to 3.9 kg of Pha-1 without TSP, respectively, at the S1 and S2 substrate levels. With respect to the combination of treatments (TSP and substrate input), exports averaged 5.7 and 6.1 kg of Pha-1, respectively, at the S1 and S2 substrate levels. At Man, P exports vary on average from 2.8 to 4.6 kg of Pha-1 depending on the doses of TSP applied without the addition of substrate. They range from 2.8 to 3.4 kg of Pha-1 and 2.8 to 3.7 kg of Pha-1 without TSP, respectively, at the S1 and S2 substrate levels. According to the combination of treatments (TSP input and substrate), exports average 5.4 and 5.5 kg of Pha-1, respectively, at the S1 and S2 substrate levels. The variance analysis of phosphorus exports shows significant differences in TSP and substrate levels, both in Abengourou and Man. The application of LSD to TSP and substrates at the threshold of 5 pc gives the P100 treatment and the incorporation rate of 30 pc of substrate the highest P exports to

Abengourou, the P75 treatment, and the incorporation rate of 30 pc of substrate, those of Man.

The insignificant differences between the P75 and P100 treatments on the one hand, the substrate incorporation rates of 15 pc and 30 pc at the two sites, on the other hand, confer, respectively, on the P75 treatments and 15 pc of the substrate. , the optimal contributions.

Table 7: Export of P (kg ha-1) according to composite soil treatments (Abengourou)

Treatment	Adding of TSP					Average
	P0	P25	P50	P75	P100	
SA	3,3	4,7	5,4	6,0	6,3	5,2
SAS1-5	3,4	4,9	5,7	6,2	6,6	5,4
SAS1-10	3,5	5,1	5,7	6,6	6,9	5,6
SAS1-15	3,8	5,5	6,2	7,3	7,3	6,0
SAS1-30	3,8	5,5	6,5	7,4	7,1	6,0
Average SAS1	*3,6*	*5,2*	*6,0*	*6,9*	*7,0*	*5,7*
SAS2-5	3,5	5,0	5,7	6,4	6,7	5,4
SAS2-10	3,0	5,2	5,9	6,4	7,0	5,5
SAS2-15	4,0	5,4	6,4	7,5	7,4	6,1
SAS2-30	3,9	5,6	6,3	7,3	7,5	6,2
Average SAS2	*3,6*	*5,3*	*6,1*	*6,9*	*7,1*	*6,1*
Average SAS	*3,6*	*5,3*	*6,1*	*6,9*	*7,1*	*5,9*
Average	**3,5c**	**5,1b**	**5,8b**	**6,6a**	**6,8a**	**5,7**

Online averages followed by different letters, differ significantly (P < 0,05)

Table 8: Export of P (kg ha-1) according to composite soil treatments (Man)

Treatment	Adding of TSP					Average
	P0	P25	P50	P75	P100	
SM	2,8	4,1	5,0	5,5	4,6	4,4
SMS1-5	3,0	4,5	5,4	6,0	6,3	5,0
SMS1-10	3,1	4,9	5,7	6,3	6,6	5,3
SMS1-15	3,3	4,9	5,9	6,6	7,1	5,5
SMS1-30	3,4	5,1	6,0	6,9	6,4	5,6
Average SMS1	*3,2*	*4,9*	*5,7*	*6,4*	*6,6*	*5,4*
SMS2-5	3,2	4,7	5,5	6,0	6,3	5,1
SMS2-10	3,3	5,0	5,8	6,4	6,7	5,4
SMS2-15	3,6	5,2	6,1	6,9	7,0	5,7
SMS2-30	3,7	5,4	5,9	6,9	7,2	5,8
Average SMS2	*3,4*	*5,0*	*5,8*	*6,5*	*6,8*	*5,5*
Average SMS	*3,3*	*5,0*	*5,8*	*6,5*	*6,7*	*5,4*
Average	**3,1d**	**4,7bc**	**5,5b**	**6,2a**	**6,0ab**	**5,1**

Online averages followed by different letters, differ significantly (P < 0,05)

3.5 Rate of use and agronomic efficiency

♣ **Apparent rates of use of the TSP** Substrates effectively contribute to P uptake, despite the apparent low rates of use of TSP inputs in composite soils (Table 9). Apparent rates of TSP use are relatively higher in Man than in Abengourou. The higher the dose of TSP applied, the lower the rate of use. These utilization rates range from 5.6 p.c. (P25) to 3.1 p.c. (P100), and from 6.1 p.c. (P25) to 2.9 p.c. (P100), respectively, in Abengourou and Man. In addition, the apparent rates of use of TSP are higher with the contribution of substrate S1 compared to the substrate S2. The analysis of the variances of utilization rates shows a significant difference in treatment. The application of LSD at the 5% threshold at apparent TSP use rates gives the P25 treatment the highest rates in both Abengourou and Man.

♣ **Agronomic efficiency**

- Agronomic effectiveness of TSP

The agronomic efficiency is on average high. The addition of organic substrate increases the agronomic efficiency of TSP. It decreases with increasing doses of TSP applied, but remains slightly higher in Man than in Abengourou. It is also higher at substrate 1 than at substrate 2 (Table 10). The agronomic efficiency ranges from 21.6 kg (P25) to 10.2 kg (P100) of rice grains per kg of applied P, and from 23.0 (P25) to 10.7 (P100) kg of grain of rice per kg of P applied, respectively, to Abengourou and Man.The analysis of the agronomic efficiency variances shows a significant difference in the treatments, and particularly for the TSP and substrate inputs, as well as their combination. The application of LSD at the 5-point threshold gives the P25 treatment and the S2 substrate the highest agronomic efficiencies in both Abengourou and Man.

- Agronomic effectiveness of substrates

The incorporation of substrates into the soil contributes effectively to rice production. The average agronomic efficiency of the substrates is high (Table 10). It increases with the rate of incorporation of substrates, reaches a maximum at treatment P75 (14 and 12.8 kg of rice per unit of substrate, respectively, in Man and Abengourou), and at the rate of 15 p.c. (14.2 and 11.4 kg of rice per unit of substrate, respectively, in Man and Abengourou) whatever the nature of the substrate, before decreasing. The agronomic efficiency remains higher in Man than in Abengourou, and more in the substrate S1 than the substrate S2. The analysis of the agronomic efficiency variances of the substrates shows a significant difference as regards the doses of TSP, the substrate levels used as well as their combination. Application of LSD at the 5 p.c. threshold gives the P75 treatment and 15 p.c. substrate incorporation the highest agronomic efficiencies.

Table 9: Apparent rates of use of TSP (p.c.)..

Parameters	Treatment TSP			
	P 25	P 50	P 75	P 100
Abengourou				
SA	5,8	4,3	3,7	3,1
SAS1	6,5	4,8	4,3	3,3
SAS2	6,9	5,0	4,4	3,6
SAS	6,7	4,9	4,4	3,5
Average	6,4a	4,7b	4,1bc	3,3d
Man				
SM	5,0	4,5	3,6	1,8
SMS1	6,7	5,1	4,3	3,4
SMS2	6,5	4,8	4,2	3,4
SMS	6,6	4,9	4,3	3,4
Average	6,1a	4,8b	4bc	2,9d

Online averages followed by different letters, differ significantly (P < 0,05)

Table 10: Average agronomic efficiency of TSP (in kg of rice / kg of P applied) according to substrate inputs

	Treatment TSP			
Parameters	P 25	P 50	P 75	P 100
Abengourou				
SA	20,7	14,9	12,8	9,8
SAS1	22,6	16,1	13,8	10,5
SAS2	21,5	15,7	14,6	10,2
SAS	22,1	15,9	14,2	10,4
Average	21,6a	15,6b	13,7bc	10,2c
Man				
SM	22,7	16,7	13,2	10,8
SMS1	23,5	16,7	13,8	10,8
SMS2	*22,6*	*16,7*	*14,2*	*10,5*
SMS	23,1	16,7	14,0	10,7
Moyenne	23,0a	16,7b	13,8bc	10,7c

Online averages followed by different letters, differ significantly (P < 0,05)

4.Discussion

The significant contribution of available phosphorus to increased yields in acidic soils of moist forest regions is proven, as the findings of this study attest, and is the result of many authors (Gervy, 1970, Von Uexküll and Muttert., 1995, Sahrawat, 2006, etc.). Unfortunately, the availability of phosphorus in the soil in general and in acidic soils in particular is not solely due to the quantities of P in the form of phosphate fertilizers (Brady and Weil, 2002) or organic amendments (Iratcabat M., 2000), but most importantly, the resultant of different equilibrium reactions (Gervy, 1970), and the action of many factors (Mkhabelaa and Warman, 2005) in which P would be involved. Thus, at Man, the soil pH, below 4.5, promotes the solubility of iron and aluminum oxides and hydroxides (Hewitt, 1952) in large quantities in soils, and results in the release of Al3 + and Fe3 + ions. . The fixation of these ions with phosphorus (Kuo 1990, Tisdale et al., 1993) would reduce its availability for the nutrition of rice plants. This results in low rates of P use. These results confirm those of Vance et al. (2000) according to which the P utilization rates involved in nutrition would be less than 20 pC for good phosphate fertilization. The contributions of TSP, a soluble fertilizer used for phosphate fertilization, allow immediate availability of P, but are largely fixed by metal ions. The combined contributions of organic substrates and soluble fertilizers could make P more available by the occupation of the P binding sites by the argilo- humic complex on the one hand; on the other hand, from the mobilization of P resulting from the mineralization of the organic matter and the shifting of equilibrium reactions according to the law of Stockes. The results for these composite soils in terms of P export and yields confirm, on the one hand, the work of Hooda et al. (2001) that a combination of compost and soluble fertilizer inputs would increase the amount of P available. The same

is true of the work of Damodar et al., (1999), according to which an annual application of these two components would lead to an increase in the mineral and organic fractions of P in the soil (Chen et al., 2007) while reducing the sites for fixing metal ions thanks to the ions present in the organic matter. However, the effectiveness of the organic matter would come in addition to its quantity and its role of occupation of the sites of fixation of the metal ions, its high pH, likely to influence that of the soil, and thus to leave the zone of action of these ions. Ultimately, the availability of P in acid soils in moist forest regions would be significantly dependent on the ability of soils to fix or release P (Brady and Weil 2002, Agbenin 2003, Gielser et al. This capacity would be regulated by a set of equilibrium reactions.

5.Conclusion

Rice growth and development is generally dependent on the availability of nutritious minerals, particularly P, in acidic soils in moist forest regions. The availability of P, however, is related to many factors including the ability of these soils to fix and release P. Unlike soluble fertilizers whose application allows to temporarily and effectively dispose of a tiny fraction of P the combined supply of P with residual substrates to the production of edible fungi of the Pleurotus Eous variety makes it possible to increase the availability of phosphorus for plant nutrition.The experiment conducted on a rice culture from a combination of P with two residual substrates, in particular S1 and S2 provided at different doses to two acidic soils from Man and Abengourou, made it possible to elucidate this assertion. - above. It follows from this experiment that the effectiveness of the substrate depends on its nature, its pH and its rate of incorporation. Thus, grain and straw yields are maximum for a feed of 100 kg ha-1 regardless of the incorporation rate of residual organic substrate S1.

It is the same for a supply of 75 kg ha-1 P whatever the level of S2 substrate incorporation. Man composite samples allow maximum grain and straw yield for incorporation of 30 µl of S2. Those of Abengourou allow the same yields for incorporation of 15 p.c. of S1 or S2.

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